Portland Cement Association Sustainable Manufacturing Fact Sheet

July 2005

Concrete Thinking for a sustainable world

PCA Portland Cement Association

POWER PLANT BYPRODUCTS

Resource efficiency means using fewer virgin raw materials. Increasingly, cement plants are turning to industrial byproducts and materials that otherwise would be discarded as sources for the basic elements needed for cement making.

After completing detailed analyses on their chemical characteristics to determine the effect on process chemistry and facility emissions, many cement plants can utilize byproducts from the electric power industry as a raw material in the manufacture of the clinker—the intermediate product in the process—or as an ingredient in the final cement product.

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Three general classes of byproducts from electric power plants can be used in the manufacture of portland cement: fly ash, bottom ash/boiler slag, and flue gas desulfurization (FGD) materials.

Fly ash and bottom ash/boiler slag contain large amounts of silica and alumina as well as calcium and iron [TFHRC 2002]. All of these components are needed in the cement manufacturing process. FGD materials can replace the natural gypsum that must be added to the final product to control the setting of concrete [EPRI 1999]. Currently, over 55% of U.S. portland cement plants use one or more of these byproducts to produce clinker or cement.

Fly Ash

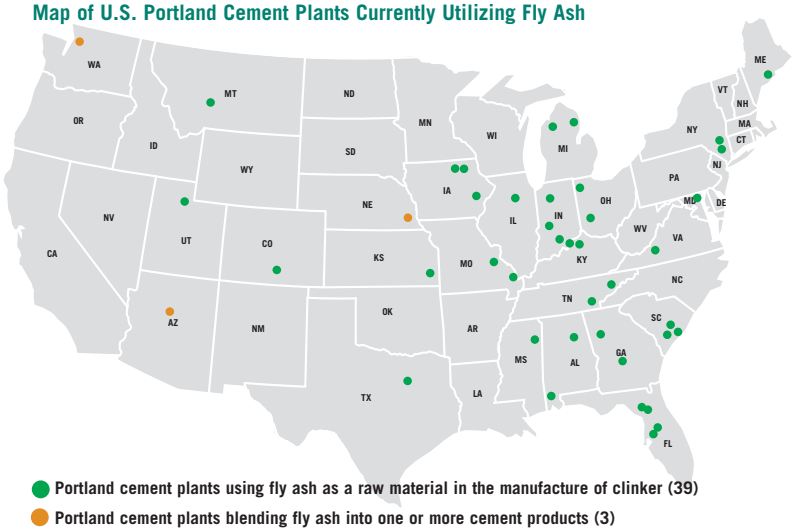
Fly ash is the fine, powder-like material collected by the particulate matter control devices at coal-burning power plants. Depending on chemical and physical attributes, some fly ash can be blended into the final cement product or used at the ready-mixed concrete plant. In the appropriate proportions in concrete, fly ash decreases permeability and increases long-term strength [ACAA undated].

The American Coal Ash Association (ACAA) reported that 70 million short tons of fly ash was produced in 2003, with over 12 million short tons used in concrete, concrete products, and grout. Over 3 million short tons of fly ash was used in kiln feed for the manufacture of clinker or cement [ACAA 2004].

In 2005, 39 portland cement plants were using fly ash as a raw material in the manufacture of clinker, and 3 plants were blending fly ash into one or more cement products. (Figure 1 shows the locations of the plants utilizing fly ash.)

FIGURE 1

Map of U.S. Portland Cement Plants Currently Utilizing Fly Ash



Bottom Ash and Boiler Slag

These materials are collected in the bottom of coal furnaces at electric power plants. Bottom ash is a dark gray or black, sand-like material that collects in the bottom of dry-bottom boilers. Boiler slag is retained as a molten material in wet-bottom boilers and is discharged into quenching water where it crystallizes and fractures into black glassy pellets [TFHRC 2002].

Nearly 20 million tons of bottom ash and boiler slag was produced in the United States in 2003. Over 500,000 tons of it was used in kiln feed for the manufacture of clinker and over 310,000 tons used in concrete, concrete products, and grout [ACAA 2004].

In 2005, 21 portland cement plants were using bottom ash / boiler slag as a raw material in the manufacture of clinker (as shown in Figure 2).

THE CEMENT-MAKING PROCESS

Portland cement manufacturing is a four-step process:

1. Raw materials, including limestone and small amounts of sand and clay, come from a quarry usually located near the cement manufacturing plant. Limestone is typically about 80% of the raw mix and is the primary source of calcium.The remaining raw materials provide the silica and the necessary small amounts of alumina and iron.
2. The materials are carefully analyzed, precisely combined and blended, and then ground for further processing. This is called kiln feed.
3. The ground materials are heated in an industrial furnace, called a kiln, that reaches gas temperatures of 1,870°C (3,400°F). The heat causes the kiln feed to turn into a new substance called clinker. The kiln flame is fueled by powdered coal, powdered petroleum coke, natural gas, oil, and/or recycled materials burned for energy recovery.
4. Red-hot clinker is cooled and ground with a small amount of gypsum and typically other mineral components. The end result is a fine, gray-colored powder called portland cement.

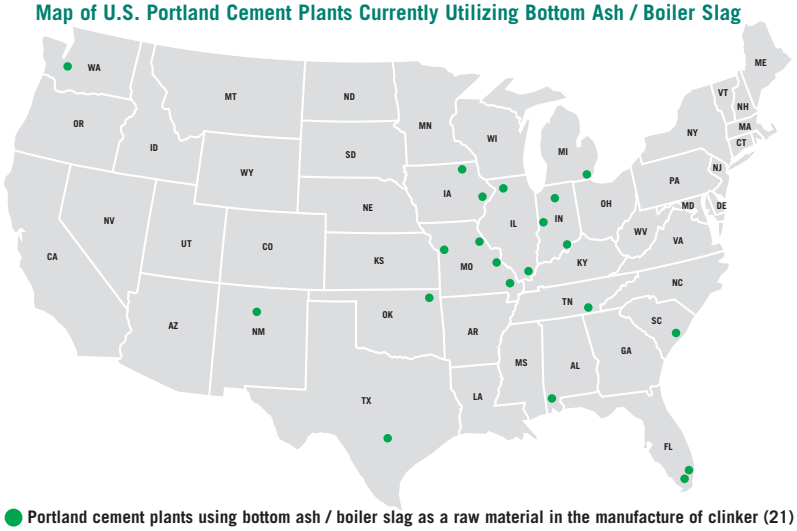
At each stage, process data are continuously monitored to produce a high-quality product, improve energy efficiency, and minimize emissions.

CEMENT OR CONCRETE?

The terms cement and concrete are often misused. Cement is an ingredient of concrete. It is the fine gray powder that, when mixed with water, sand, and gravel or crushed stone, forms the rock-like mass known as concrete. Cement acts as the binding agent or glue.

FIGURE 2

Map of U.S. Portland Cement Plants Currently Utilizing Bottom Ash / Boiler Slag



Portland cement plants using bottom ash / boiler slag as a raw material in the manufacture of clinker (21)

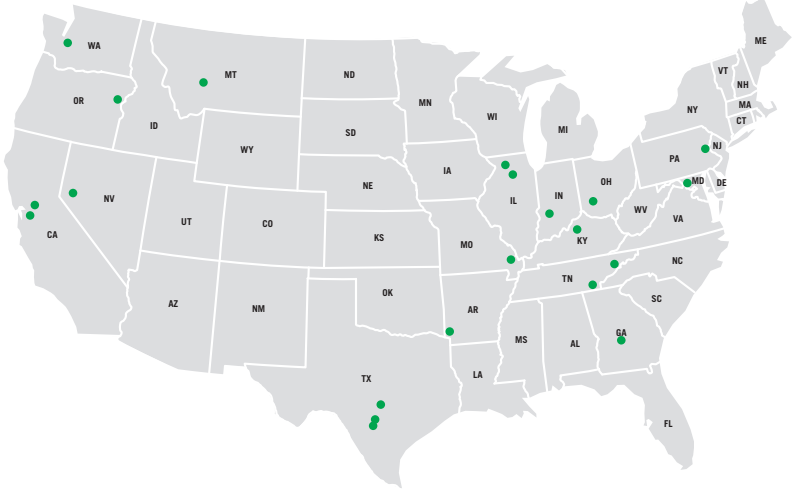
Flue Gas Desulfurization Materials

At some coal-fired power plants, sulfur dioxide emissions are controlled by flue gas desulfurization (FGD) systems in which lime or limestone reacts with the gaseous sulfur to form calcium sulfate or calcium sulfite. This material is referred to as synthetic gypsum. When properly processed, the calcium sulfate can be used at portland cement plants to replace the natural gypsum that must be added to the final product to control the setting of concrete [EPRI 1999].

In 2003, over 420,000 tons of synthetic gypsum from FGD systems was used at portland cement plants out of the nearly 12 million tons produced by the electric power industry [ACAA 2004]. In 2005, 20 portland cement plants were using FGD materials in the cements (as shown in figure 3). | more

FIGURE 3

Map of U.S. Portland Cement Plants Currently Utilizing Flue Gas Desulfurization Materials



Portland cement plants using FGD materials blending fly ash in one or more cement products (20)

USE OF POWER PLANT BYPRODUCTS

The Buzzi Unicem plant in Chattanooga, TN, uses all three byproducts from coal-fired power plants: fly ash, bottom ash, and synthetic gypsum. The fly ash and bottom ash are part of the kiln feed and become part of the clinker, while the gypsum is used in the finish mills in the production of portland cement.

USE OF SYNTHETIC GYPSUM

The synthetic gypsum produced by coal-fired power plants is often a moist material. At the CEMEX plant in Knoxville, TN, it is mixed with cement kiln dust—a byproduct from the production of clinker—to improve material handling. The result is a powder that can be added to the clinker in the finish grinding mill to produce portland cement. This allows the beneficial use of two byproducts: one from the electric power industry and the second from the cement manufacturing process.

FOR ADDITIONAL INFORMATION PLEASE CONTACT:

Portland Cement Association
1130 Connecticut Avenue, Suite 1250
Washington, DC 20036-3925
Voice: 202.408.9494
Fax: 202.408.0877
E-mail: sustainablemanufacturing@cement.org

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Concrete Thinking for a sustainable world

PCA Portland Cement Association

Portland Cement Association is a trade association representing cement companies in the United States and Canada. PCA's U.S. membership consists of 46 companies operating 102 plants in 36 states. PCA members account for more than 97% of cement-making capacity in the United States and 100% in Canada.

Portland Cement Association

5420 Old Orchard Road
Skokie, Illinois 60077-1083
847.966.6200 Fax 847.966.9781

1130 Connecticut Avenue, Suite 1250
Washington, DC 20036-3925
202.408.9494 Fax 202.408.0877

www.cement.org

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